CORELLA

Journal of the Australian Bird Study Association

VOLUME 15 MAY, 1991 NUMBER 2

Corella, 1991, 15(2): 33–36

THE ROSEATE TERN *Sterna dougallii gracilis* BREEDING ON THE NORTHERN GREAT BARRIER REEF QUEENSLAND

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Received 21 July 1989

In the tropical environment on the northern Great Barrier Reef, Queensland, Roseate Terns *Sterna dougallii* laid eggs from November to January. The average clutch size was 1.6. This did not vary significantly in the three breeding seasons from 1983 to 1986. Adults fed their young predominantly silver, schooling bait-fish from 25 mm to 125 mm in length. Feeding rates increased in two breeding seasons to compensate for smaller prey sizes available in these seasons. Pre-fledging survival rates of chicks were extremely low in breeding seasons when feeding rates were high. Survival of chicks was generally low.

INTRODUCTION

There has recently been concern over the decline of Roseate Tern *Sterna dougallii* populations throughout the world (Gochfield 1983). Nisbet (1980, 1981) listed some fundamental aspects of their biology, and drew attention to the endangered status of the species. Yet, published information on the breeding biology of the Roseate Tern is largely fragmentary (Gochfield 1983), and little is known about their survival or demography (Nisbet 1981). Serventy *et al.* (1971) described the biology and ecology of Roseate Terns in Australian waters. Hulsman (1977) reported on their survival at One Tree Island on the Great Barrier Reef, Queensland.

Within Australia, Roseate Terns are distributed from the West Australian coast north of Cape Leeuwin, breeding as far south as Fremantle, along the coast of north Australia to the eastern coast and south to Lady Musgrave Island on the southern Great Barrier Reef, Queensland, with vagrants occurring further south (Blakers *et al.* 1984; Storr *et al.* 1986). In the eastern part of this range Roseate Terns nest with the morphologically (Pringle 1987) and ecologically similar Black-naped Tern *Sterna sumatrana* (Smith 1989).

This paper provides data on breeding, feeding and survival of chicks at a small Roseate Tern colony on a sand cay of the northern Great Barrier Reef, Queensland, Australia.

METHODS

All data were collected at a low vegetated cay, Eagle Island (14°42′S, 145°23′E). A description of the island has been given by Smith and Buckley (1986).

Information was collected from Eagle Island on 83 of the 133 intervening days, between 1 November 1983 and 12 March 1984; on 86 out of the 136 day period between 25 October 1984 and 9 March 1985; on 15 October 1985; between 27

November and 6 December 1985; and finally from 28 December 1985 to 9 March 1986 when checks were made on 49 of the 72 intervening days.

Each nest containing eggs was individually marked. Nests were subsequently monitored for hatching eggs and the dates of laying were calculated from hatching dates, assuming a 22-day incubation period as described by Nisbet (1981). Chicks were individually identified by coloured and numbered metallic leg bands on or shortly after the date of hatching. The breeding area was subsequently surveyed repeatedly for surviving chicks.

Specific broods were observed through binoculars from a hide. The number of fish fed to broods, the size of fish (estimated relative to adult bill length) and the type of fish (either silver, schooling bait fish, or coloured, reef fish) were recorded for each hour of observation.

Fledging success was estimated as the percentage of chicks surviving to 15 days. It was assumed that birds surviving to 15 days fledged successfully even though fledging takes longer. A figure for fledging success using a later age could lead to survival being underestimated as young could have fledged without detection.

RESULTS

Breeding

The number of clutches produced in each breeding season at Eagle Island is given in Table 1. Nesting density was low, concurring with the low numbers of adult birds in breeding plumage. Nests were shallow depressions lined with grass. These were typically found under or beside low bushes just above the level of High Water Spring tides. Clutches comprised either one or two eggs (Table 1), with an average of 1.6 eggs per nest (SD = 0.5, n = 41; data from all years pooled). The ratio of one-egg to two-egg clutches did not differ significantly among years ($\chi^2 = 0.9$, df = 2, $P > 0.05$) and overall (data pooled from all years) there was no significant difference between the number of one-egg and two-egg clutches ($\chi^2 = 1.2$, df = 1, $P > 0.05$).

TABLE 1

Number of completed clutches of each size for the breeding seasons through 1983–1986 at Eagle Island. The pooled mean was 1.6 (SD = 0.5, n = 41). Results of χ^2 tests were as follows: (a) χ^2 test of independence, $\chi^2 = 0.9$, df = 2, $P > 0.05$, (b) χ^2 test of 1:1 ratio in pooled data, $\chi^2 = 1.2$, df = 1, $P > 0.05$.

	C/1	C/2	Unknown	Total
1983–1984	5	6	—	11
1984–1985	4	9	1	14
1985–1986	8	9	1	18
Pooled	17	24	2	43

Eggs were laid during the months of November, December and January, all years pooled (Table 2). However, there was a difference of up to 19 days in the timing between years. In 1983–1984, egg-laying commenced 17 November and was spread over 37 days; in 1984–1985, it started 24 November and lasted 44 days; in 1985–1986 the first egg was laid 6 December and laying continued for 17 days.

Feeding and diet

Fish were returned one at a time to broods. All fish (n = 192) delivered by adults were 'silver' (i.e. schooling bait-fish). These ranged in size from one quarter to two-and-a-half times the average adult bill length of 50.0 mm (SD = 1.7, n = 6).

TABLE 2

Dates on which eggs were laid (where known) during three breeding seasons at Eagle Island.

Date of laying	No. of eggs	Date of laying	No. of eggs	Date of laying	No. of eggs
17/11/83	1	24/11/84	2	6/12/85	1
28/11/83	1	27/11/84	3	7/12/85	1
29/11/83	1	28/11/84	2	11/12/85	3
1/12/83	1	29/11/84	2	12/12/85	1
4/12/83	2	30/11/84	1	13/12/85	1
8/12/83	1	1/12/84	2	14/12/85	1
10/12/83	1	4/12/84	1	15/12/85	1
11/12/83	1	4/ 1/85	1	16/12/85	3
12/12/83	1	6/ 1/85	2	19/12/85	3
23/12/83	1			21/12/85	1
				22/12/85	2

TABLE 3

The sizes of prey fed to Roseate Tern chicks during each of three breeding seasons.

Season	Mean (mm)	SD (±)	n	Range (mm)
1983–1984	64.5	25.0	60	25.0–125.0
1984–1985	43.5	14.0	76	16.5– 75.0
1985–1986	22.0	10.0	26	12.5– 50.0

The size of prey fed to chicks (Table 3) differed between each breeding season (Kruskal-Wallis test: $H = 70.73$, $df = 2$, $P < 0.05$. Mann-Whitney U tests: 1983–1984 vs 1984–1985, $Z = 5.3$, $P < 0.05$; 1983–1984 vs 1985–1986, $Z = 6.9$, $P < 0.5$; 1984–1985 vs 1985–1986, $Z = 6.1$, $P < 0.05$). There was a substantial decrease in prey sizes over the three years of study (Table 3).

Overall (data pooled across years: Table 4) feeding occurred at a rate of 0.93 fish per hour in the case of C/1 broods (i.e. clutch size of one) and almost twice this (1.70 fish per hour) in C/2 broods (i.e. clutch size of two). The rate of feeding of C/1 broods did not differ significantly among years (Kruskal-Wallis test: $H = 1.19$, $df = 2$, $P > 0.05$), but did for C/2 broods ($H = 6.05$, $df = 2$, $P < 0.05$). The frequency of feeding was significantly greater in 1984–1985 than 1983–1984 (Mann-Whitney U test: $Z = 1.96$, $P = 0.05$).

Survival

Fledging success was highest in 1983–1984 (23.5%) compared with 1984–1985 (4.5%) and 1985–1986 (3.8%) (Table 5).

TABLE 4

Feeding rates (fish per hour) per brood (C/1 and C/2) for each of three breeding seasons studied at Eagle Island.

Season	C/1 Mean	C/1 SD	C/1 Sample	C/2 Mean	C/2 SD	C/2 Sample
1983–4	0.76	0.95	62	1.04	1.40	23
1984–5	1.38	2.00	34	1.57	1.25	30
1985–6	0.57	0.65	14	4.12	4.94	8
Pooled	0.93	1.37	110	1.70	2.30	61

DISCUSSION

Between 1983 and 1986, egg-laying by Roseate Terns occurred in the months of November, December and January at Eagle Island. Breeding coincided with that of the Black-naped Tern (Smith and Buckley 1986; Smith 1989, 1990), with which the Roseate Tern were associated at Eagle Island, although Black-naped Terns nested in far greater numbers (1983–1984: 103 clutches, 1984–1985: 335 clutches, 1985–1986: 58 clutches, Smith and Buckley 1986).

Fresh Roseate Tern eggs have been recorded in February (Walker and Hulsman 1982), March (King, pers. comm.), April (Walker and Jones 1986); chicks (in some cases recently dead) in June and August (King, pers. comm.); and 'nesting' in October (King, pers. comm.) on the Great Barrier Reef. Thus breeding has been recorded in nine months of the year. It would appear that the Roseate Tern could be an opportunistic breeder on great Barrier Reef islands.

At Eagle Island, Roseate Terns laid on average 1.6 eggs per nest (cf. 1.8 in Massachussetts and 1.5 in northeastern North America, northwestern Europe and the Caribbean; Nisbet 1981), and thus similar to that of the Black-naped Tern (cf. 1.6; Hulsman and Smith 1988). Roseate Tern clutch sizes did not differ significantly between breeding seasons (similar to the Black-naped Tern; Hulsman and Smith 1988).

Roseate Terns evidently feed close to their colonies (Hulsman 1984) as do Black-naped Terns (Smith 1989, 1990). At Eagle Island, both species fed their chicks predominantly on silver, schooling bait-fish of similar sizes (Hulsman and Smith 1989). Silver, schooling bait-fish appear to be their main diet within Australian waters, given

TABLE 5

Average survival rates per brood for each of the three breeding seasons studied at Eagle Island.

Season	C/1 Mean	C/1 SD	C/1 Sample	C/2 Mean	C/2 SD	C/2 Sample
1983–4	0.4	0.55	5	0.2	0.27	6
1984–5	0	0	4	0.1	0.17	9
1985–6	0	0	8	0.1	0.17	9

that museum specimens from Western Australia contained sprats (Fam. Clupeidae), billfish (either swordfish, Fam. Xiphiidae or marlin Fam. Istiophoriidae), *Sardinops neopilchardus* (Fam. Clupeidae) and *Spratelloides gracilis* (Fam. Clupeidae) in their guts when collected. A detailed analysis of diet in Australian waters still needs to be undertaken.

At Eagle Island, prey of significantly different sizes were fed to chicks in each of the three breeding seasons, decreasing in size from 1983 to 1986. A similar result was obtained for Black-naped Terns (Smith 1989). The frequency of feeding of C/2 broods increased across the seasons, suggesting that to compensate for the smaller prey returned parents had to work harder. This probably led to considerable strain on adults and chicks, producing the very low fledging rates in the latter two seasons of this study. Fledging rates observed at Eagle Island were in general low but not atypical of survival rates elsewhere on the reef. Hulsman (1977) and B. King (pers. comm.) have also recorded high juvenile mortality. Survival rates at Eagle Island were well below those reported in the USA (60–100% success; Nisbet 1981). Low survival on the reef could simply reflect a natural failure of the food supply and/or density-dependent survival of young (Ashmole 1971; Safina *et al.* 1990). Alternatively, Roseate Terns may be in competition with the ecologically and morphologically similar Black-naped Tern, which could explain why Roseate Terns are more abundant on the West Australian coast where Black-naped Terns are absent. However, the Roseate Tern also appears to be an ecological specialist in its feeding habits (Safina 1990) and this could explain low numbers and survival on the Great Barrier Reef.

ACKNOWLEDGMENTS

I wish to thank the staff of the Lizard Island Research Station for logistical support. Nick Dunlop and Kees Hulsman gave constructive comments on the manuscripts. I am also grateful to Brian King for his comments and unpublished data, and to Jeff Leis for advice on fish identification. Financial assistance was received from a Lizard Island *Reader's Digest* Doctoral Fellowship, the Ecological Society of Australia, the Great Barrier Reef Marine Park Authority, the M. A. Ingram Trust, the Commonwealth Postgraduate Research Award and Griffith University.

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